

# HYDROLOGIC UNIT MAPPING IN GEORGIA

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**Abstract.** Standardized definitions of hydrologic unit areas are available nationwide and are broadly used in watershed studies; however, these hydrologic units are too large to serve many water-resource investigation and management needs. A standardized, digital data base of accurately and consistently defined hydrologic units is needed for smaller watershed areas. Criteria for selecting watersheds as hydrologic units, and methods of delineating hydrologic unit areas are being developed and documented. Hydrologic unit areas in Georgia are being delineated and digitized for watersheds at each of two size levels smaller than the existing hydrologic unit map.

## INTRODUCTION

As the natural hydrologic boundaries for surface-water runoff, watersheds are broadly used as spatial boundaries for investigations and management programs of surface-water resources. A watershed approach supports scientific investigations and management efforts on topics such as non-point and point source contaminant loading, ecosystem function, and coordinated partnerships among stakeholders whose interests are joined by a watershed boundary that concentrates surface-water resources.

In the United States, watersheds larger than 700 square miles (except in Alaska) have been delineated and defined by the U.S. Geological Survey (USGS) on a published series of 1:500,000 scale maps. The Hydrologic Unit map for Georgia (U.S. Geological Survey, 1975) defines hydrologic units at four levels of resolution. The first level of hydrologic units (HUs) divides the State into the South Atlantic Gulf drainage region and the Tennessee drainage region; each referenced by a 2-digit number. The second level of HUs divides Georgia into 9 major drainage sub-regions, referenced by the 2-digit regional code plus a 2-digit sub-region code. In the third level delineation, 12 HUs are referenced by a 6-digit code (two digits added to the sub-region code); and in the fourth level delineation, 52 HUs are referenced by an 8-digit code. These fourth level, 8-digit HUs are broadly used in water-resources investigations and management to store, retrieve, index, and inventory hydrologic information. The 8-digit HU boundaries are standardized and registered as a Federal Information Processing Standard.

## Problem

The 8-digit hydrologic unit areas are standardized and broadly used; however, the areas are too large to adequately serve many water-resource investigation and management needs. The focus of many water resource issues is based upon diffuse pollutant loading and land-surface processes, and the cumulative effects of diffuse pollution over space and time. The Georgia Department of Natural Resources, Environmental Protection Division (EPD) reports that non-point sources of pollution account for the majority of stream miles identified with violations of water-quality standards (Environmental Protection Division, 1996). Management of these issues requires working with watersheds smaller than those defined by the 8-digit hydrologic units. Programs that require smaller watershed definitions include the EPD River Basin Management Plan, the USGS National Water-Quality Assessment Program, the Natural Resource Conservation Service (NRCS) Conservation Programs defined in the 1996 Farm Bill; and various programs under the Environmental Protection Agency, Office of Water.

Smaller watershed boundaries can be defined on a program-driven basis by each of these and other individual investigations; however, there are several benefits to coordinated, standardized hydrologic units developed using consistent criteria and methods. The Soil Conservation Service (SCS, reorganized as the NRCS) subdivided the standardized 8-digit hydrologic units, and added 3 digits to the 8-digit parent watershed number to designate 11-digit hydrologic units. The SCS published a map showing the 11-digit watersheds (Soil Conservation Service, 1990); however, it has not been broadly accepted as a standard for use. Standardized hydrologic unit definitions will enable different management and investigative programs to more efficiently share information and resources, and to coordinate activities that contribute to an overall watershed management approach. Standardized hydrologic unit definitions may be essential to coordinated watershed protection and restoration where water quality is limited due to the cumulative effects of several activities and processes. Consistent, accepted criteria and methods must be developed for the tasks of watershed selection, watershed boundary delineation, and digitization.

Consistent criteria and methods will permit standardized hydrologic units to be defined by the diverse group of investigators involved in watershed management.

The objective of this ongoing project is to provide a digital, standardized base of watershed boundaries up through the fifth and sixth level (10- and 12-digit) hydrologic unit scale, using documented, consistent methods. Documenting and obtaining consensus on the criteria and methods used in this study and on the specific watersheds selected as hydrologic units, is a significant part of the ongoing work. The EPD and several Federal agencies are participating in this project that is being coordinated by the USGS, and partly funded by EPD.

#### **Georgia Interagency Hydrologic Unit Group**

The Georgia Interagency Hydrologic Unit Group first met in 1994 to promote a digital, standardized base of watershed boundaries for Georgia, and to provide a forum for consensus among Federal and State agencies to provide a broadly accepted result. This group met twice in 1996 and participated in the Southeast Hydrologic Unit Delineation Meeting that was attended by professionals representing several State and Federal agencies involved in HU mapping from Georgia, Tennessee, Florida, Alabama, North Carolina, and South Carolina. This meeting provided a forum for discussion and consensus regarding HU mapping products, acceptable HU mapping methods, and needed coordination between State and Federal agencies for this work.

The NRCS has made a significant contribution to efforts of the Georgia Interagency Hydrologic Unit Group and national groups to promote a digital, standardized base of watershed boundaries. In order to promote standardized criteria for hydrologic unit selection and delineation, the NRCS has distributed a working draft of its National Instruction 170-304: "Mapping and digitizing watershed and subwatershed hydrologic unit boundaries", first issued in July 1992. The NRCS, the USGS, and other Federal and State agencies also are working to establish an Interagency Standard for Hydrologic Unit Mapping. The discussion in this paper of criteria for hydrologic unit selection and delineation is not comprehensive and is refined from the NRCS guideline and from the related draft interagency guidelines.

#### **CRITERIA FOR SELECTING HYDROLOGIC UNITS**

Selection of watersheds for delineation and standard definition as HUs requires good hydrologic judgement. The diversity of hydrologic conditions and the number of factors involved in the process preclude detailed definition of specific methods. Criterion for selecting HUs are intended to help guide hydrologic judgement and to define typical results for different conditions. Draft guidelines cover a much broader range of criteria than those discussed here, which were selected for the their particular relevance to work in Georgia.

The primary criterion for selection of hydrologic unit areas is that they are defined along true hydrologic watershed boundaries. A hydrologic unit has a single flow outlet (except in

coastal areas), and all flow occurs perpendicular to the boundaries. When possible, watersheds selected as hydrologic units will be "pure"; that is, whole watersheds without subdivided upstream areas and only one outlet. In addition to this primary criterion, there are also general criterion for the number of hydrologic units subdivided from a parent unit; for the size of hydrologic units; and for treatment of several factors such as non-contributing areas, and "unconsolidated" areas.

#### **Number and size of hydrologic units**

The typical number of fifth level, 10-digit HUs within a fourth level, 8-digit HU will be from 5 to 15; and the typical size of 10-digit HUs will be from 40,000 to 250,000 acres. The typical number of sixth level, 12-digit HUs within a fifth level, 10-digit HU will be from 5 to 15; and the typical size of 12-digit HUs will be from 10,000 to 40,000 acres. The relative size of HUs of a given level should be consistent in regions of similar hydrography.

#### **Selection of downstream end of hydrologic units**

The best and most obvious HUs are those that define major tributaries to the larger "parent" HU area. When choosing between small tributaries for HU definition, higher order streams typically will be chosen. In any case, the downstream end of the hydrologic unit will be the confluence with the main stem of the higher-level HU if possible; or with the mainstem of a same level HU. HUs defined with an outlet other than along the main stem of the "parent" HU often create unconsolidated HU areas around the mainstem.

#### **Hydrologic units around large reservoirs**

A difficult condition arises where large reservoirs impound parts of several hydrologic units (particularly at the 12-digit scale). A downstream HU boundary along the impounded waterline (for example, at mean reservoir level) does not provide a single outlet point, is not fixed in terms of the physical drainage (due to reservoir-level fluctuations), and is a poor criterion for the upstream end of large reservoirs where the reservoir/river boundary definition is subjective. The criterion to be used for reservoirs is to define the HU as if the impoundment did not exist. Within the impounded area, the downstream outlet point for the HU should be at the confluence of the tributary HU with the mainstem, following the artificial flow paths of the tributary and mainstem. Artificial flow paths are part of a nationwide Geographic Information System (GIS) coverage that is completed in draft form for Georgia.

#### **Unconsolidated areas**

The delineation of HUs will result in small remnant areas around the mainstem of larger streams, even when good hydrologic judgement and other factors described above are used. These unconsolidated areas also have been referred to as "related contributing drainage areas". Unconsolidated areas typically occur as wedge-shaped areas along interfluvial regions between adjacent watersheds. They also occur in coastal areas that are outlet to several mainland or island watersheds that are

individually smaller than defined for a given HU level. If the combined size of adjacent, physically unconsolidated areas is in the range of the HU level being defined, then they should be combined into a single HU. If the areas are relatively small, then they should be included within a larger, adjacent HU.

#### METHODS OF HYDROLOGIC UNIT DELINEATION

The drainage boundaries of watersheds selected for definition as HUs are delineated by interpreting topographic and hydrographic details (contours, elevations, drainage patterns) from maps. Surface runoff occurs perpendicular to these boundaries, so the boundaries cannot be defined along rivers or streams. HU boundaries must not be defined to align with administrative, political, or project boundaries. This discussion covers only selected topics, and draft NRCS and interagency guidelines provide more complete discussion of HU delineation methods, quality control, and quality assurance.

HU boundaries in Georgia are delineated on original 1:24,000-scale USGS topographic maps, using the most recent edition available. Topographic maps originally printed (not copied from paper) on scale-stable media are desirable, but not essential where cost or time constraints limit their use. Selection of fifth-, and sixth-level HU watersheds typically is easiest using maps showing hydrography and the fourth-level, 8-digit HU boundaries at a 1:500,000 scale or (using a GIS plot) a smaller scale—between 1:100,000 and 1:500,000. In Georgia, 1:200,000 scale GIS plots showing hydrography, the 8-digit HU boundaries, and corner locations of the associated 1:24,000-scale USGS quadrangle maps were very useful for selecting watersheds and identifying the approximate location of boundaries on the 1:24,000-scale maps.

#### Non-contributing and indeterminate areas

Areas that do not have an identifiable surficial drainage outlet are non-contributing areas. Non-contributing areas typically occur in Georgia's karst topographic regions. Non-contributing areas that are large enough to be defined as a separate HU area should be delineated as such. Otherwise, small non-contributing areas that are significant to the hydrology within a specific HU can be measured and the non-contributing area noted as an attribute of the associated HU.

Surface runoff may be indeterminate at the scale of fifth- or sixth-level HUs in some regions of Georgia, such as the Okefenokee Swamp. In such regions, an artificial drainage boundary would not be valuable within the otherwise hydrologically defined HU coverage. A fifth- or sixth-level HU around an indeterminate drainage area may be identical to the next higher level HU boundary definition.

#### PROGRESS AND PLANS

The process of developing digital, standardized HU definitions at the 10- and 12-digit HU scale requires the following tasks (including quality-control and quality-assurance procedures) for each HU scale: (a) select watersheds for HU definition (includes multi-agency review, revisions, and

consensus); (b) delineate HU boundaries on 1:24,000 maps; (c) digitize all HU boundaries from 1:24,000-scale maps; and (d) develop and attribute GIS coverages for each level of HU for use in water-resources investigations and management. The fourth-level, 8-digit hydrologic unit boundaries from the 1:500,000 Hydrologic Unit Map for Georgia (U.S. Geological Survey, 1975) have been delineated on 1:24,000-scale maps for the entire State. GIS coverages are complete for the 8- and 10-digit HU boundaries for the Chattahoochee and Flint River basins. Work is underway to complete the standardized digital HU definitions through the sixth level, 12-digit HUs for the Chattahoochee, Flint, Tallapoosa, Coosa, and Oconee basins. The Georgia Interagency HU Group plans to complete this work over the next 2 to 4 years.

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